VOL. XVIII. JULY, 1893. NO. 7.

THE BOTANICAL GAZETTE

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[ISSUED JULY 15.]

BLOOMINGTON, INDIANA.
PUBLISHED BY THE EDITORS.

Tracy, Gibbs & Co., Printers, Madison, Wisconsin.

THE BOTANICAL GAZETTE.

A Monthly Journal Embracing all Departments of Botanical Science.

ANNUAL SUBSCRIPTION, $2.50.

SINGLE NUMBERS, 25 CENTS.

The subscription price is an invariable one, no concession being made to dealers or agents.

In Great Britain, 11 shillings.	In Germany, 11 marks.
Agent, W. P. COLLINS, 157 Great Portland St., London, W.	Agents, R. FRIEDLÆNDER & SOHN, Carlstrasse 11, Berlin, N. W. 6.

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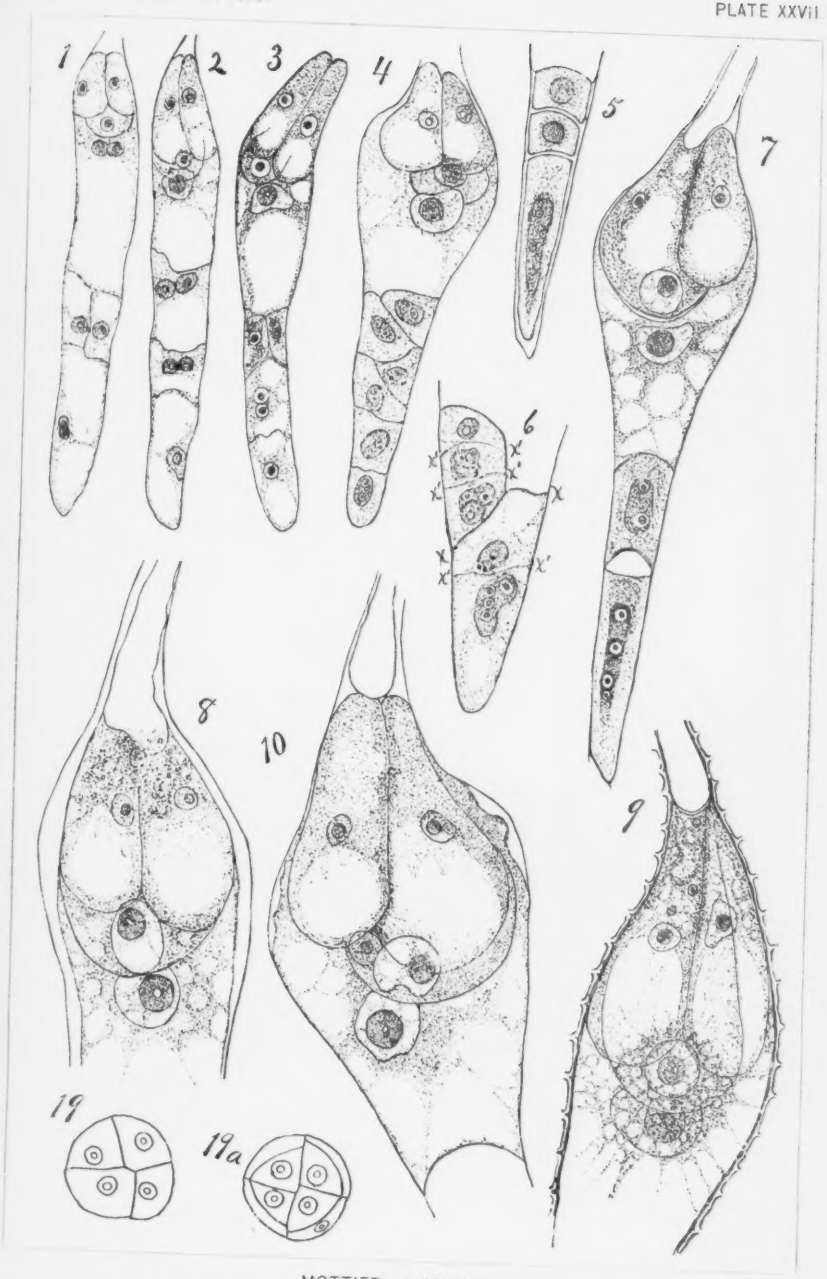

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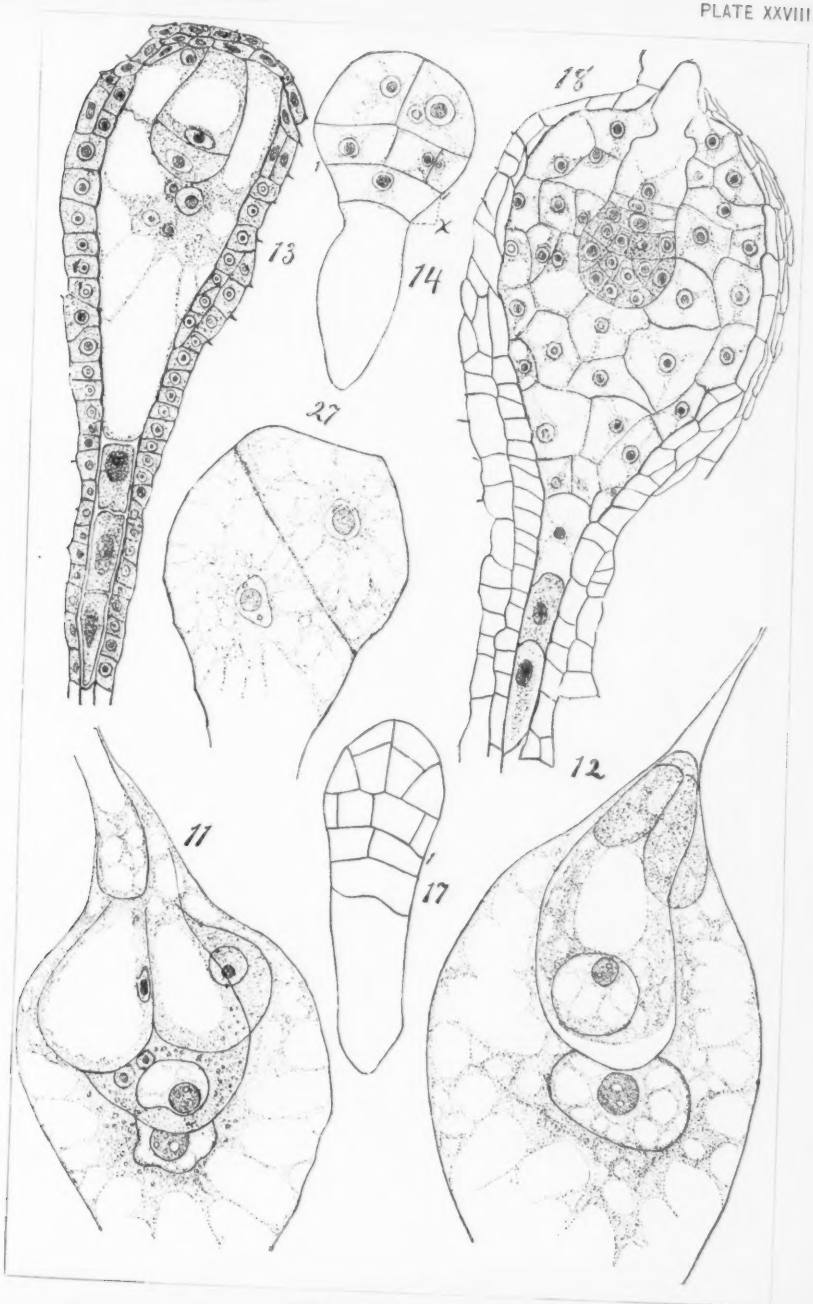

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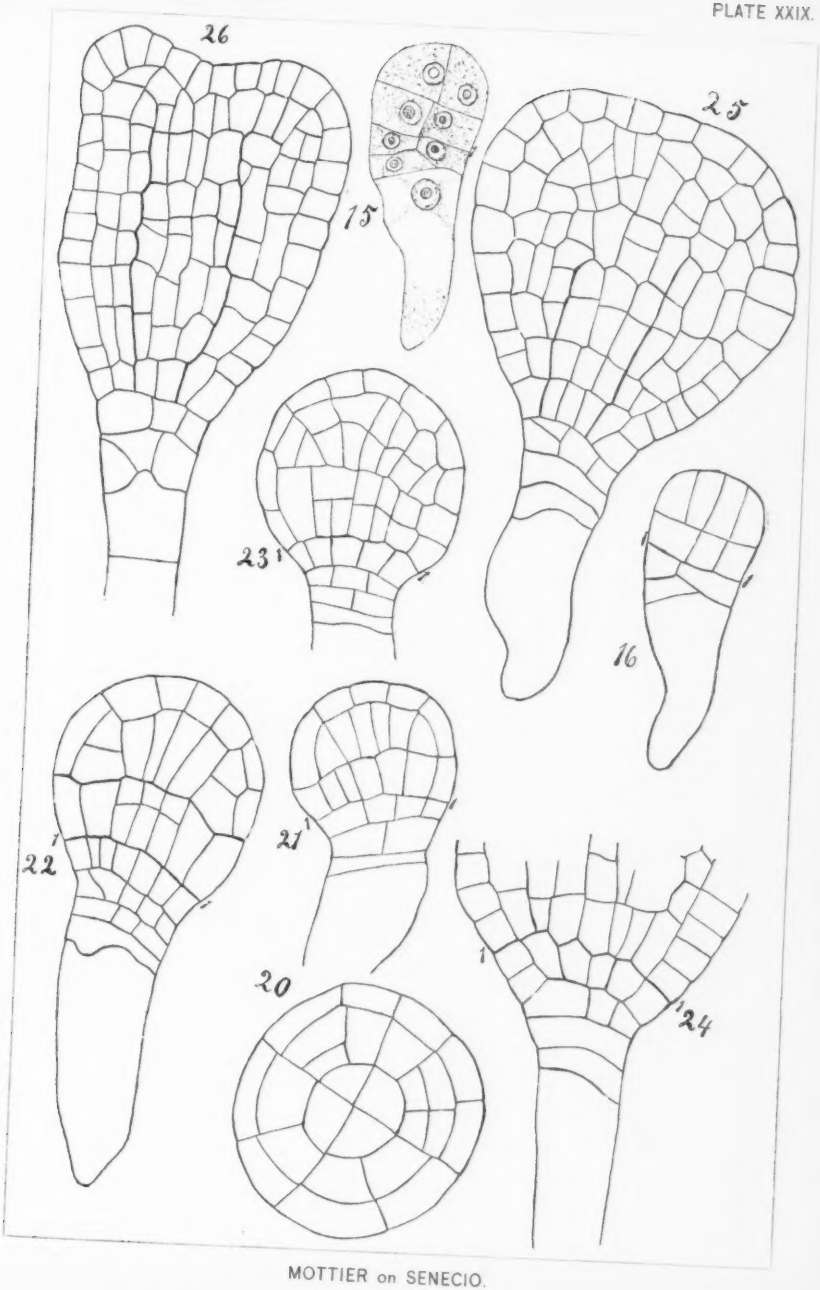

MOTTIER on SENECIO.

BOTANICAL GAZETTE

JULY, 1893.

On the embryo-sac and embryo of Senecio aureus L.

DAVID M. MOTTIER.

WITH PLATES XXVII–XXIX.

We are made familiar with the structure and development of the embryo-sac and the process of fertilization in the angiosperms by Dr. Eduard Strasburger in his masterly works, "Angiospermen und Gymnospermen," "Zellbildung und Zelltheilung," and "Theorie der Zeugung." Of the great number of plants taken as illustrative types in only one of the Compositæ are the details of the development of the embryo-sac given, namely, *Senecio vulgaris*. The Compositæ, and, it may be said, the dicotyledons in general, present many difficulties in the study of these processes.

I have observed, however, that *Senecio aureus* L., a very common native American species, is a very favorable object for the study of the embryo-sac and the early stages in the development of the embryo. Work upon this plant was undertaken chiefly for the purpose of comparison with that which obtains in some of the lower dicotyledons and monocotyledons and to see whether the process here differed in any way from that of the allied species, Senecio vulgaris, according to the account given by Strasburger.

According to our present state of knowledge the typical seven-celled embryo-sac is a structure that stands isolated in the plant kingdom. Whether this is the same for all angiosperms is not known, and, if any variation from the type exists, it is highly probable that it occurs in some of the lowest dicotyledons or monocotyledons. Unfortunately, however, in none of the lowest of those forms is the development of the embryo-sac known, and a study of this process in the lowest forms of the above named groups is beyond question necessary.

Since my results agree closely with those of Strasburger upon *Senecio vulgaris* a brief *résumé* of the latter may be for convenience given here.[1]

As will be indicated below, I am here concerned only with the nearly mature and mature embryo-sac, and such facts only as pertain to it will be mentioned. In the nearly mature embryo-sac the two synergidæ occupy the entire forward pointed end of the embryo-sac. Under these lies the egg, occupying usually the entire diameter of the embryo-sac. The antipodal cells completely fill the hinder end of the embryo-sac. They lie in a longitudinal row, or two above and one below. The lower antipodal cell gives rise to a large hinder vacuole as a cell lumen. Its nucleus lies in the protoplasm lining the wall, at about one-half the height of the cell lumen. The two nuclei given off to the inner part of the embryo-sac approach each other quickly to unite just as the embryo-sac approaches maturity. When this state of maturity is reached the embryo-sac swells considerably at its middle part. The synergidæ have now rounded themselves off somewhat at the forward end, and appear here strongly refractive. Their nuclei lie in the hinder third. By the swelling of the embryo-sac, the egg has become free at its hinder part. The lowest antipodal cell usually divides once before the mature state is reached, so that there are now four antipodal cells. Frequently, however, only the nucleus divides without being followed by a cell division.

The embryo-sac.

In preparing the material for this work heads of flowers were gathered in the stage of development desired, halved and treated for about twelve hours (usually over night) in a one per cent. aqueous solution of chromic acid. After thorough washing, they were gradually brought into ninety-five per cent. alcohol. The material was stained *in toto* with alum cochineal, imbedded (through xylol) in paraffin and sectioned on a Minot microtome. The sections were counter-stained on the slide and mounted in balsam. In this way serial sections were made of a large number of florets, and not infrequently were several stages of the young embryo obtained upon a single slide as well as mature embryo-

[1] Angiospermen und Gymnospermen, 1879, pp. 9, 10, 11. Zellbildung und Zelltheilung, dritte Auflage, 1880. pp. 42, 43.

sacs. We are concerned here with the mature embryo-sacs, and with that stage in the development just before the nuclei given off to the interior, unite to form the endosperm nucleus. The earlier stages in the development observed agree with that which obtains in Senecio vulgaris according to Strasburger and will not be repeated here.

The two synergidae and egg-cell occupy the somewhat anterior pointed end of the embryo-sac (figs. 2, 3, 8, 9.). The synergidæ are somewhat pear-shaped, being narrower at the anterior end, where they are also rounded. In all cases observed the anterior ends of the synergidæ never appeared refractive, but filled with granular protoplasm which stained only slightly with alum cochineal, but stained readily with Bismarck brown. The posterior part of each of the synergidæ is occupied by a large vacuole which reaches fully half the length of the cell and probably extends farther forward than it seems. The vacuole does not take up the entire posterior part of the cell, but a delicate layer of protoplasm forms an inner lining of the cell. The nuclei lie imbedded in this protoplasmic lining about midway between the anterior and posterior ends. In no case were they observed in the posterior third as Strasburger states for Senecio vulgaris.

The egg-cell is similar in form to the synergidæ, though inserted a little lower, the posterior part occupying, in the many cases observed the entire diameter of the embryo-sac. The protoplasm is accumulated in the posterior end in which is imbedded the egg-nucleus, while the vacuole is in the anterior end. Thus in the egg-apparatus there is a sort of equilibrium maintained in the distribution of the protoplasm. The nucleus has a large nucleolus which stains so deeply with alum cochineal as to appear a homogeneous red, except there is invariably present from one to several highly refractive bodies resembling drops of oil. This may be due to the reagents used in preparing the tissue for sectioning and not to normal products of the nucleolus. Surrounding the nucleolus is a zone of slightly stained protoplasm, and finally the nuclear membrane which appears with great clearness. The nucleus is usually spherical though frequently compressed on one side, due probably to contraction caused by reagents (fig. 10). In nearly all preparations there was no shrinkage whatever.

When the embryo-sac is mature it swells considerably at its middle, so that the egg-apparatus is free behind.

The antipodal cells occupy the entire posterior end of the embryo-sac, which is narrow and always remains so (figs. 5, 7, 13). As in Senecio vulgaris, they lie in a longitudinal row (fig. 5), or one below and two above (figs. 1, 3); but I find here a much greater variation in the number of cells than Strasburger figures for Senecio vulgaris. In several instances only two cells were present (fig. 7), separated by a much swollen wall. The lower cell is longer than the upper and the nucleus is greatly lengthened in the direction of the axis of the embryo-sac; it contains several nucleoli and may have arisen from the fusion of two nuclei. Fig. 3 shows an embryo-sac in which the lower antipodal cell has divided, and in the upper one of these the nucleus has doubled. The doubling of the nuclei in the antipodal cells is, however, a frequent occurrence. In fig. 4 it will be seen that each antipodal cell has divided, making six in all. A curious condition of things is shown in fig. 6. The wall, x, was well developed, but the others, x', x', were extremely delicate.

In many cases the walls separating the antipodal cells were slightly swollen (fig. 5). These facts seem to indicate that the antipodal cells represent a structure that shows a tendency toward further development, suggesting a much reduced prothallium or rudimentary structure of some kind, and a comparison of it with a prothallium of the vascular cryptogams seems reasonable.

The fusion of the two nuclei to form the endosperm nucleus takes place after the formation of the egg apparatus and antipodal cells. In no case were the antipodal cells observed lying free without cell walls at the time when the nuclei were about to unite to form the endosperm nucleus; the walls were always well developed at this stage.

Of the two nuclei given off into the cavity of the embryo-sac, the one which comes from the antipodal end traverses the greater distance and meets its fellow close to the egg-cell where they unite (fig. 1). The endosperm nucleus invariably lies very near the egg, apparently touching it in many cases (figs. 4, 8, 9, 10). Its structure is similar to that of the egg nucleus, except it is much larger in every respect. It is surrounded by rather dense granular protoplasm from which radiate delicate threads connecting with the very delicate layer of protoplasm lining the cavity of the sac. In this particular fig. 9 is the most interesting. Here a very

beautiful net-work of protoplasm seems to radiate from the region of the egg nucleus, though between it and the observer, almost obscuring the endosperm nucleus lying beneath.

Fertilization.

Senecio aureus is by no means a very favorable object for the study of the process of fertilization. As is well known, the dicotyledons as a rule, present here many difficulties. Either the ovules are opaque, necessitating sectioning, or the nuclei in the pollen tube as well as the tube itself are extremely small. In Senecio aureus and the Compositæ in general both of these difficulties confront the observer. However, by the aid of a 2^{mm} oil immersion I was enabled to demonstrate the presence of the pollen tube in the micropyle and the generative nucleus after it had entered the egg-apparatus. In no case was the presence of a pollen tube in the style or any part of the ovary wall observed, consequently the exact path followed by it was not determined. The end of the tube was seen just as it had reached the anterior ends of the synergidæ (figs. 7, 8, 9, 10). Its membrane is extremely delicate and the tube collapses soon after the contents have left it. The contents now spread out upon the anterior ends of the synergidæ, make them appear more densely granular (figs. 8, 9). The generative nucleus as it leaves the pollen tube, appears as a very small and slightly stained mass of nuclear substance (fig. 8). By the time it has reached the egg nucleus, however, it has increased considerably in size (fig. 10), having been nourished by the contents of the egg apparatus. In the preparation represented in fig. 9, the presence of a pollen tube was quite evident, the anterior ends of the synergidæ densely granular, but no definite nucleus could be seen. Two small bodies more densely stained than the rest are present, which take on the character of nuclear substance.

The wall of the micropyle just in front of the synergidæ stained a homogeneous brown (not shown in the figures), suggesting strongly the presence of a mucilaginous substance, which in all probability is secreted by the synergidæ. In fig. 10 the generative nucleus is seen lying close to the egg-nucleus. In fig. 11, two, though smaller, nuclei are seen. Even at this stage in the process, the synergidæ seemed very little changed, except their membranes were extremely del-

icate and almost indistinguishable. In fig. 11 the synergidæ on the left showed disorganization, the nucleus being smaller and vacuole larger.

Development of the embryo.

The fertilized egg, oospore, increases in size, becomes slightly elongated, and develops a more definite membrane (fig. 12). The posterior part (that directed toward the micropyle) now protrudes slightly into the micropyle to serve as an organ of attachment. The nucleus increases now greatly in size as does the endosperm nucleus also. The synergidæ are almost entirely absorbed; their remains are shown in the figure. The oospore now divides near its upper end (that directed away from the micropyle) by a transverse wall into a terminal hemispherical cell and a basal cylindrical cell (fig. 13). The terminal cell forms the greater part of the future embryo, while the basal cell forms the suspensor and a part of the embryo. This differs from that which obtains in *Capsella*[2] in that the oospore does not elongate into a tube which first divides by a number of cross walls to form the suspensor. Here the suspensor remains shorter; it is composed of fewer cells and the divisions take place later. At this stage of development (fig. 13), several free nuclei have arisen in the cavity of the embryo-sac from the division of the endosperm nucleus.

This terminal cell of the embryo, after further increase in size, divides into halves by a longitudinal wall. This is followed by a second longitudinal wall at right angles to the first, as will be seen in a cross section of the same at a similar stage of development (fig. 19). A third wall, transverse, follows at right angles to the first two. The terminal cell has now divided into eight cells, which may be compared to the octants of a sphere. From the upper half of the embryo which is cut off by the transverse wall, proceeds subsequently the epicotyledonary (plumule and cotyledons) portion of the embryo, and from the lower, the hypocotyledonary (radicle) portion. At this stage of development (fig. 14) a cell is cut off from the upper end of the suspensor by a transverse wall. This cell, *x*, subsequently contributes to the formation of the periblem of the root, the root cap and suspensor. The three walls mentioned above which divide the original terminal cell

[2] Goebel: Outlines of Classification and Special Morphology, English translation, 1887, pp. 396, 397, 398.

of the embryo into octants follow each other rapidly; for in different flowers of the same head, embryos as represented in fig. 13 were very frequently found along with those developed as far as shown in fig. 16 or farther. The stage figured in fig. 14 was rarely met with.

The usual form of the embryo at this stage of development is that which is figured in figs. 17, 18, the figures representing longitudinal sections.

Each of the four upper cells of the embryo is now divided into two by anticlinal walls (fig. 16). Immediately following this each cell of the embryo is separated into an inner and outer cell by its periclinal wall (figs. 18, 21). The outer row of cells is the dermatogen or young epidermis; its cells divide henceforward only by walls at right angles to the outer surface, i. e., anticlinal walls, no periclinal walls being formed. The inner cells are the initial elements of the periblem and plerome, which are very early distinguishable from each other. This may be plainly seen in fig. 22, and in fig. 20, which is a cross section of a young embryo. The cells of the periblem and plerome now divide by both longitudinal and transverse walls, the divisions being quite regular for a time (figs. 22, 23), but as the embryo increases in size they become less regular (fig. 25).

The cell divisions which take place in the cell *x*, fig. 14, do not seem to follow with as great regularity as in Capsella. It divides once or twice by transverse walls (figs. 18, 21, 23, 24), and the cells thus formed divide further by longitudinal walls, though with no great regularity (figs. 22, 24). Whether any cell or cells are cut off from the upper part of the large cell of the suspensor could not be determined, as the nucleus was not seen in process of division. However, as above stated, it contributes to both embryo and suspensor.

The suspensor consists of few cells, usually three or four, the lower one remaining large and cylindrical, and projecting slightly into the micropyle (figs. 18, 22, 25). In fig. 26 the first appearance of the cotyledons is seen; the limits of periblem and plerome are indicated by heavy lines. Thus at this stage of development those parts which are to become the root, stem and cotyledons are quite apparent (figs. 25, 26), even as early in the development as represented in figs. 21, 22. Further development of the embryo was not followed.

The endosperm.

As stated in the foregoing, several free nuclei appear in the cavity of the embryo-sac when the first wall is formed in the embryo. Very soon, however, cell formation takes place, and the cavity of the embryo-sac is entirely filled with endosperm (fig. 18). In some cases the embryo was further developed than others before cell formation took place in the endosperm. The process of cell building here is that of the Capsella type.[3] This is not a favorable object for the study of the details in the process of cell-formation. I was not able to make out the "Verbindungsfäden" of Strasburger.[4] Fig. 27 shows two endosperm cells that occupied the whole width of the embryo-sac in which was the embryo, fig. 16. Figs. 27 and 16 were taken from consecutive sections. Around each nucleus (fig. 27) whose membrane is somewhat contracted, is an accumulation of protoplasm from which radiate delicate protoplasmic threads.

The endosperm cells are relatively large and not very rich in protoplasm. The layer of cells forming the wall of the embryo-sac, which is the modified adjacent part of the integument of the ovule, is rich in protoplasm, nuclei and contents staining densely with cochineal stain. The neighboring cells of the integument soon begin to disorganize (fig. 18).

Very noticeable is the fact that here the antipodal cells are not absorbed during the formation of the endosperm, but persist throughout. They were in the perfectly normal condition even when the embryo had reached the size figured in fig. 26, and the endosperm had been somewhat absorbed. The end of the embryo-sac occupied by them remains narrow, but widens abruptly above them (fig. 18).

Here the behavior of the antipodal cells seems very peculiar. Just what they represent in the angiosperm embryo-sac is still a mystery, and it seems to me that at present the facts are insufficient to justify speculation. We must wait, at least, until the development of the embryo-sac is known in the lowest forms of the angiosperms.

University of Indiana, Bloomington.

EXPLANATION OF PLATES XXVII–XXIX.

Figs. 8, 9, 10, 11, 12, 20, ×560 diam. Figs. 13, 18, ×280 diam.; all the rest ×405 diam.—Fig. 1. Embryo-sac just before the formation of the endosperm

[3] Zellbildung und Zelltheilung, dritte Auflage, 1889, p. 11.

[4] Strasburger: Ueber Befruchtung und Zelltheilung, 1878, p. 71.

nucleus.—Figs. 2, 3. Embryo-sacs just before the flower opens, measuring .152^{mm} in length.—Fig. 4. Antipodal cells divided, the two upper by oblique walls.—Fig. 5. Elongated nucleus of the lower antipodal cell.—Fig. 6. Peculiar condition of antipodal cells; the wall *x* well developed; *x'*,*x'*, very delicate.—Fig. 7. Embryo-sac at the time of fertilization, .216^{mm} long by .048^{mm} wide.—Figs. 8, 11. Upper part of embryo-sac showing egg-apparatus, endosperm nucleus and pollen tube.—Fig. 12. Fertilized egg; synergidae disappearing.—Fig. 13. Embryo-sac with two-celled embryo.—Fig. 18. Embryo further developed, surrounded by endosperm tissue. Figs.—14, 17. Embryos in different stages of development; 1—1 primary transverse wall.—Figs. 19–20. Transverse section of upper end of young embryo; in 19a and 20 the four cells forming the inner circle are the plerome; the next outer row the periblem; and in 20 the outermost row the dermatogen.—Figs. 21–26, longitudinal sections of older stages of the embryo; in figs. 25 and 26 the heavier lines indicate the boundary between plerome and periblem.—Fig. 27, two endosperm cells.

Descriptions of new species of Uredineæ and Ustilagineæ, with remarks on some other species. I.

P. DIETEL.

The following described species of fungi, principally Uredineæ, have been collected by Mr. E. W. D. Holway and some other collectors in California and several other portions of the United States. Three other new species, namely, *Uromyces aureus* Diet. and Holw., *Puccinia Holwayi* Diet., and *Puccinia Delphinii* Diet. and Holw., have already been published in Hedwigia, XXXII (1893). 29, 30.

Ustilago Holwayi Diet. n. sp.—Spore masses black-brown, pulverulent, destroying the whole inflorescence. Spores subglobose or obovate, brown, with large warts, 8–13μ in diameter.

On *Hordeum pratense*. Camp Badger, Calif., July, 1892, leg. *Holway*.

From the similar *Ustilago Lorentziana* Thüm. (Mycotheca univ. no. 1711) this differs, as an examination has shown, by the shape of the epispore.

Puccinia rufescens Diet. and Holw. n. sp.—Spots none. Æcidia forming loose and irregular groups, or isolated on both sides of the leaves. Pseudoperidia hemispherical, with decaying edges, composed of oblong, loosely aggregated cells. Æcidiospores mostly ovoid or obovate, with a light brownish membrane, containing orange red protoplasmic contents,

minutely verrucose, 18–25×17–20μ. Teleutospores: sori amphigenous, mostly around the aecidial groups, reddish brown, pulverulent, first covered by the elevated epidermis, soon naked, irregular in form and size, measuring from 1–6^{mm}. Spores rounded at the apex and base, distinctly constricted at the septum, with a tuberculated epispore, apical thickening little or none, 32–46×21–31μ. Pedicels hyaline, very deciduous, as long as the spores. Unicellular spores are of frequent occurrence.

On leaves and bracts of *Pedicularis semibarbata.* Kings River Cañon, Calif., July 15, 1892, leg. *Holway.*

This is the third Puccinia known at the present time on Pedicularis. The other two are *Puccinia Clintoni* Peck on *Pedicularis Canadensis* in America, and *Puccinia Pedicularis* Thüm. on *Pedicularis Œderi* in Asia. The American species differs in having a smooth epispore with a papilla at the apex, the Asiatic by the form of the teleutospores. In neither have æcidia been observed.

Puccinia intermedia Diet. and Holw. n. sp.—Spots none; sori amphigenous, circular, 0.33–0.75^{mm} in diameter, scattered, sometimes confluent, dark brown, containing uredo- and teleutospores. Uredospores broadly ovate or subglobose, finely echinulate, brown, 21–23×17–23μ. Teleutospores oblong, mostly rounded on both sides, sometimes protracted in a hyaline papilla at the apex, distinctly constricted at the septum, verrucose, brown, apical thickening not very considerable, often nearly wanting, 32–40×17–23μ. Pedicels deciduous.

On *Epilobium* sp. Kings River Cañon, Calif., July, 1892, leg. *Holway.*

Puccinia intermedia is in some respects intermediate between *Puccinia pulverulenta* Grev. and *Puccinia Epilobii* DC. From P. Epilobii it differs in the manner of attacking the host plant, in possessing a uredosporic fructification and having the spores much less constricted; P. pulverulenta differs by the smooth epispore and other properties of the teleutospores.

Puccinia Californica Diet. and Holw. n. sp.—Sori amphigenous, scattered, without discoloration of the nourishing plant, almost concealed by the pubescence of the host plant, if occurring on the under side of the leaves; roundish or oblong, ca. 1^{mm} in diameter. Uredospores very uniform, globose or shortly elliptical, dark brown, very thickly but finely

echinulate, 26–31×26μ. Teleutospores forming black sori; spores rounded on both sides or somewhat attenuated below, slightly constricted, chestnut brown, thickened very slightly, if at all, around the apical germ-pore, tuberculated, 42–52×26–36μ. Pedicels long (up to 125μ), colorless, rather deciduous. Amongst the bicellular teleutospores occur often unicellular ones.

On *Cnicus Breweri*. Kings River Cañon, Calif., July 14, 1892, leg. *Holway*.

From all similar species on Compositæ known to the writer this Puccinia is easy to be distinguished by the darker colored and much more densely echinulate epispore of the uredoform. In the form and size of the teleutospores it has most resemblance to the European *Puccinia Cirsii lanceolati* Schröt.

Puccinia Cymopteri Diet. and Holw. n. sp.—Attacking all parts of the host plant. Sori black-brown, very pulverulent, soon naked, at first covered by the grayish epidermis. Teleutospores ovate or oblong, sometimes irregular, rounded on both sides, hardly constricted in the middle, slightly verrucose, deep brown, 33–45×20–27μ. Pedicels short, deciduous.

On *Cymopterus terebinthinus*. Kings River Cañon, Calif., July, 1892, leg. *Holway*.

This species is distinctly different from *Puccinia Jonesii* Peck, which in Dr. Farlow's Provisional Host-Index is said to occur on *Cymopterus bipinnatus*.

Puccinia Polemonii Diet. and Holw. n. sp.—Amphigenous, sori roundish, scattered, 0.5–2.5^{mm} in diameter. Two kinds of teleutospores are formed; the ones, principally in the centre of the sori, with a colorless or nearly colorless membrane thickened at the apex and with firm long pedicels, germinating directly, are fusiform and little constricted at the septum before germinating; the others, with deciduous pedicels, germinating, as it seems, only after a period of rest, are yellowish brown in color, obovate or fusiform, distinctly constricted and surmounted with a conical, hyaline papilla. Epispore smooth, 29–45×12–17μ. On an average the colored spores are broader than the colorless ones.

On leaves of *Polemonium cæruleum*. Kootenai County, Idaho, July, 1892, leg. *J. H. Sandberg*.

PUCCINIA CLARKIÆ Peck.—Of this species, not recorded by De Toni in Saccardo's Sylloge Fungorum, hitherto only

teleutospores have been described. Mr. Holway has collected beautiful specimens of this fungus on *Clarkia elegans* in California (Camp Badger) with uredo- and teleutospores and has sent me, too, a specimen on *Clarkia pulchella* with uredospores from Idaho, collected by Mr. Geo. B. Aiton. From these the following description is taken. Sori hypophyllous, the teleutospore layers often arranged into circles, rather long, covered by the elevated epidermis. Uredospores broadly ovate or nearly spherical, brown, echinulate, 22–29×18.5–25μ. Teleutospores oblong, upper cell rounded or obconical, sometimes with a distinct papilla, thickened at the apex in different degrees, lower cell rounded or somewhat attenuated below, central constriction little, epispore smooth, chestnut brown, 37–50×20–25μ. Pedicels firm, long.

UROMYCES BOREALIS Peck on *Hedysarum boreale* and *Hed. Mackenzii* agrees in all respects with the European *Uromyces Hedysari obscuri* (DC.).

Uredo *(Melampsora?)* **Arbuti** Diet. and Holw. n. sp.—Hypophyllous, sori densely aggregated into irregular groups, or scattered over the greater part of the leaf, not confluent, hemispherical before the epidermis is ruptured, minute, ca. 0.2^{mm} in diameter. Spores pyriform or club-shaped, colorless, filled with orange red granular protoplasm, echinulate, 28–55×15–22μ.

On *Arbutus Menziesii*. Mt. Tamalpais, Calif., April 1, 1893, leg. *W. C. Blasdale*.

Judging from the size of the spores and the general appearance, this Uredo belongs to a Melampsora.

On *Valerianella congesta* Mr. W. C. Blasdale has collected an æcidium in California (Mill Valley), which is probably the *Æcidium Valerianellæ* Biv. Bernh. The pseudoperidia are scattered over the whole underside of the leaves. The spores, appearing, if examined dry, very minutely verrucose, are subglobose or ovate and measure 17–27×15–20μ.

Leipzig, Germany.

Contribution to the biology of the organism causing leguminous tubercles.

GEO. F. ATKINSON.

WITH PLATES XII–XV.

(Concluded from p. 237.)

Comparative review.

This brings the history of the more important contributions to the biology of the leguminous tubercle organism, that have come to the notice of the present writer, down to the present time. The record presents a discouraging volume of conflicting testimony, some of it from eminent investigators. It would indeed be a misfortune should all these painstaking and laborious investigations really be so much at variance as appears from this examination of the contributions. Some of them which deny any external agent of a microbic nature will always remain important expositions of the structure and development of the tubercles. Had more attention been given by these investigators to careful cultural experiments perhaps they might have come to different conclusions. The charge might perhaps be made that cultural experiments are untrustworthy since Tschirch[97] and Frank[98] assert that sterilizing the soil by heat so changes its physical condition as to interfere with the development of the tubercles. Frank[99] and Schindler[100] also believe that the formation of the tubercles stood in direct relation to the vigor or assimilatory activity of the plants. Since plants do not usually grow so well under cultural conditions this might be said to argue against the trustworthiness of cultural experiments. In a large series of cultural experiments designed especially to test the correctness of these suggestions Prazmowski found them to be groundless. The cultural experiments carried on by the present writer show that sterilizing the soil, or a low state of vigor in the plants, will not prevent the development of the tubercles if the proper organism is given access to the roots.

In view of all the cultural experiments referred to above,

[97] Bot. Centralb. XXXI (1887).

[98] Ueber den Einfluss, welchen das Sterilisieren des Erdbodens auf die Pflanzenentwickelung ausübt. Ber. d. deutsch. bot. Gesells. VI (1888). *XCV.*

[99] Untersuchungen über die Ernährung der Pflanze mit Stickstoff. Landw. Jahrb. XVIII (1888). 496.

[100] Jour. für Landwirtschaft. XXXIII (1885). 330.

and in addition those carried on by Atwater,[101] Bréal,[102] Bertholet,[103] and Vines,[104] conviction becomes inevitable that leguminous plants can only develop tubercles when excited by the presence of certain micro-organisms.

The important question then is, can these various conflicting notions of the biology of the microsymbiont be harmonized? Leaving out of consideration for the present the real nature of the organism it will be admitted by those who take the trouble to familiarize themselves with the scope of the work covered by the most important investigations that the organism in question consists of an elongated thread-like structure, which branches freely within the tubercle and possesses enlarged portions which present a more or less finely lobed surface; and very much smaller forms which must exist to some extent within the tubercle, are capable of multiplying in artificial media, and, when transplanted from artificial media to the roots of leguminous plants, are capable, under these more natural conditions and the stimulus of the macrosymbiont, of growing out again into the thread-like structures.

Beyerinck[105] then probably overlooked the real nature of the thread-like structures. From a careful study of his illustrations and descriptions it seems reasonably certain that, in some instances at least, he was dealing with the true organism in his artificial cultures. An examination of his figure II *C* shows the organism to be very similar in form to those in my own cultures represented in figures 11 and 12, plate XIV, and to those obtained by Laurent. In describing them he says: "Die Colonien auf Gelatine bestehen aus stark gebuckelten bacteroidenähnlichen Stäbchen." The culture of this one was obtained from tubercles of *Vicia hirsuta.*

Recently Nobbe, Schmid, Hiltner and Hotter,[106] while considering the organisms to be bacteria, admit that in the

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[101] Atmospheric nitrogen as plant food. Bull. no. 5, Storrs' School Agr. Exp. Station, Conn. Oct. 1889.

[102] Fixation de l'azote par les légumineuses. Compt. Rend. herbd. d. Sci. d. l'Acad. d. Sciences, Paris. CIX. Oct. 28, 1889.

[103] Experiénces nouvelles sur la fixation de l'azote par certain terres végétales et par certaines plantes. Ann. d. Chim. et d. Phys. VI. XVI. Avril, 1889.

[104] On the relation between the formation of tubercles on the roots of Leguminoseæ and the presence of nitrogen in the soil. Ann. Botany II (1888–1889). 386–388.

[105] Bot. Zeit. 1888.

[106] Versuche über die Stickstoff-Assimilation der Leguminosen. Landw Versuchs-Stationen. XXXIX (1891).

cultures, especially from tubercles of *Lupinus*, numerous larger bacteroid forms developed. "Wir haben jedoch in unseren mehrfachen Uebertragungen Gebilde oft in grosser Anzahl gefunden, welche unzweifelhaft als echte Bakteroiden angesprochen werden mussten."

The tests imposed by Eriksson,[107] Ward,[108] Vuillemin,[109] Pichi,[110] A. Koch,[111] and Laurent[112] for the determination of the presence of a membrane in connection with the thread-like structures, would seem to impeach Prazmowski's[113] and Frank's[114] explanations of its nature. H. Möller[115] also finds a membrane on the strands but interprets it as being a cellulose membrane deposited by the protoplasm of the leguminous plant around the bacterian zoogloœa, and cites in support of this view cellulose membranes said by R. Wolff[116] to be deposited about the threads of *Ustilagineæ* by their hosts. Such a view does not seem to be any greater proof of the bacterian nature of the organism of the tubercles than of a like nature for the *Ustilagineæ*.

It is difficult also to harmonize Prazmowski's description of the organism in artificial cultures with that obtained by the majority of those who have succeeded in growing it outside of the tubercles. It would, perhaps, be unjust to infer that his cultures were contaminated; or shall we suspect him of committing the same error which he imputed to Beyerinck, *viz.*, that he was deceived in the appearance of the forked or lobed condition of the organism? Prazmowski says this appearance might be produced by one rod lying partly over another, since frequently he was for a time deceived by such appearances. Could we not then, on the same ground say that the bacteroids are not forked?

It was impossible in the case of the cultures obtained by the present writer to be deceived in the form of the organism. The rod-like forms were exceedingly rare. It would seem that Laurent's work was carefully guarded for Metchnikoff

[107] Bot. Zeit. 1874.
[108] Phil. Trans. Royal Soc. CLXXVIII; Proceed. Roy. Soc. XLVI.
[109] Ann. d. Sci. Agr. Franç. et etrang. 1888.
[110] Atti d. Soc. Toscani d. Sci. nat. 1888.
[111] Zur Kenntniss der Fäden in den Wurzelknöllchen. Bot. Zeit. 1890.
[112] Ann. d. l'Inst. Pasteur. v (1891).
[113] Landw. Versuchs-Stationen XXXVII (1890).
[114] Ueber die Pilzsymbiose der Leguminosen. Berlin, 1890.
[115] Ber. d. deutsch. bot. Gesells. x (1892). 242–249.
[116] Brand d. Getreides, 1874.

himself observed some of the lobed organisms in his cultures.

There does not seem to be any very important difference between the organisms described by Laurent and that obtained by myself. The result is the more satisfactory since the present writer did not know, at the time the organism was separated and first studied, what the real nature of Laurent's organism was. The account of the organism given by Ward agrees in all essential features with the one obtained by Laurent and myself.

Frank's mycoplasm of the tubercles is identical with the hyphæ, of course, but the reconciliation of his *Rhizobium*, a micrococcoid organism, with the forms obtained in culture by Beyerinck, Laurent and myself is not so easily effected, though the great majority of the individuals in the cultures from the tubercles of *Vicia sativa* were very small and without very high magnifying power would appear micrococcoid. The study of the form of the organism in the cultures was made with the aid of a Winkel microscope, the $\frac{1}{24}$ homogeneous immersion lens being used. A Zeiss 2^{mm} homogeneous immersion lens also served very well to bring out the definition of the form. Better results were obtained in examining the organism in a living condition, or by staining in a living condition with eosin. Killing and fixing the organism by heat on the cover glass did not give such good results because of the lack of firmness in the body of the organism.

Another question which arises, and which, if answered in the affirmative, may help to explain some of the discrepancies between the organisms in cultures by different investigators, is this: are there species or races of the microsymbiont? The bacteroids, by those who believe in the presence of a microsymbiont, are generally accepted as one form of the organism. They are regarded by Prazmowski as involution forms, because of their departure from the normal forms of rod-like bacteria. Whether or not we term them forms of involution it seems pretty certain that, when the organism has reached the firmness exhibited by the great mass of bacteroids in the tubercles, they are no longer capable of growth, since they have lost that power in becoming receptacles for the storage of proteid substance.

Prazmowski says the death of the bacteria is first announced in most cases by a change to the branched form. It would

probably be more nearly correct to say that the death of the organism, in its passage to the sterile condition of the perfect bacteroids is first indicated by a firmer condition of the organism, probably brought about by the increasing presence of proteid matter which in many cases finally becomes centered in different parts of the bacteroids and forms bodies which possess a very high power of refracting light. Lundström[117] described these in the tubercles of *Trifolium repens.* In some cases these bodies occupy nearly the entire inner portion of the bacteroids and frequently the accumulation takes place to such an extent as to cause the form of the bacteroid to enlarge, when, if there are several such bodies in an elongated bacteroid it presents a nodulose appearance as shown in some of the bacteroids from *Medicago denticulata* in figures 14 and 15 of plate XIV. In the bacteroids of species of Trifolium frequently the great increase in the size of these bodies gives to them the form of a bladder, and Beyerinck[118] has designated them as "Bläschenbacteroiden." Prazmowski shows that these bodies in the bacteroids do not take such stains as methyl violet. The present writer has observed that they do not take the stains gentian violet and fuchsin. On staining bacteroids from tubercles of *Medicago denticulata* with fuchsin they present an interrupted stain, simulating in this respect the rods of *Bacillus tuberculosus.* It is quite likely that the difficulty experienced in staining these objects in the tubercles has led some to describe the stained portions as spores.

Prazmowski calls attention to the fact that concentrated sulphuric acid will not dissolve normal bacteria, but that it will dissolve these highly refringent bodies in the tubercles giving to them a rose red color, which he claims shows them to be proteid bodies. Recently Frank[119] places them with the starch group calling them amylodextrin bodies while H. Möller,[120] in reply says they represent some form of cholesterin. In this same paper Frank states that he has discovered a dimorphism in the tubercles on the roots of peas, that the large profusely forked ones bear principally these

[117] Bot. Centralb., XXXIII (1888).

[118] Bot. Zeit. 1888.

[119] Ueber den Dimorphismus der Wurzelknöllchen der Erbse. Berichte d. deutsch. bot. Gesellsch. x (1892). 170–178.

[120] Bemerkungen zu Frank's Mittheilung über den Dimorphismus der Wurzelknöllchen der Erbse. Ber. d. deut. bot. Ges. x (1892). 242, 249.

amylodextrin bacteroids, while the smaller simple forms bear principally proteid bacteroids. H. Möller takes exception to this statement also, while Frank[121] refutes Möller's objection on the ground that Möller's study was confined to the tubercles of *Trifolium*, while Frank's announcement of a dimorphism related to the tubercles on *Pisum*.

There are many different forms of bacteroids associated with the tubercles of different species or genera of leguminous plants. As noted above Schneider has based several species of his *Rhizobium* purely on these characters of form and the more or less definite localization of the protoplasm at various points of the accumulation of these highly refringent and not readily stained bodies.

Morck,[122] while not describing them as species, figured numerous forms from tubercles of between forty and fifty species of *Leguminosæ*.

While these bacteroids are incapable of growth they may represent to a certain extent morphological characters of the organism within the tubercles. If this be true it would strengthen the proposition suggested by different forms obtained in artificial cultures that there are different varieties, or races, of the organism.

Schrœter[123] describes two species of his *Phytomyxa* based on the presence or absence of the strands in the tubercles. Some investigations of Hellriegel, Laws and Gilbert, Prazmowski (l. c.), point to a probability that lupines will not develop tubercles when seeded with soil-extract from places where lupines have not grown, while peas, etc., seeded with the same soil-extract develop the tubercles.

Beyerinck (l. c.) claims that in his artificial cultures different races were obtained which remained true to form through successive cultures.

Nobbe, Schmid, Hiltner and Hotter[124] found that *Lupinus luteus* inoculated with pea tubercle organisms, as well as those from *Robinia*, *Cytisus* and *Gleditschia*, developed no tubercles, but when inoculated with lupine tubercle organisms, devel-

[121] Ueber Möller's Bemerkungen bezüglich der dimorphen Wurzelknollchen der Erbse. Ber. deutsch. bot. Gesells. x (1892). 390–395.

[122] Ueber die Formen der Bakteroiden bei den einzelnen Spezies der Leguminosen. Inaug-Dissert. Leipzig, 1891.

[123] Kryptogamen-Flora von Schlesien, 134.

[124] Versuche über die Stickstoff-Assimilation der Leguminosen. Landw. Versuchs-Stationen xxxix (1891). 227–359.

oped tubercles. *Phascolus vulgaris* inoculated with cultures from tubercles of *Phascolus* and peas developed tubercles, but if inoculated with cultures from tubercles of *Lupinus* or *Robinia*, none were developed. In one case *Pisum sativum* inoculated with lupine tubercle organisms developed tubercles, while in other cases it did not. In the case where the tubercles were developed, the hyphæ and bacteroid characteristic of those of the peas under normal conditions were developed. If this development of tubercles on peas from lupine organisms were not an accidental contamination it would indicate that one and the same species occurred in the tubercles of peas and lupine. Other cross inoculations made by them occasionally took effect but there was shown a disposition to tardy and weak development as if the organism had been in some unsuitable condition.

At the same time that the present writer carried on the second experiment in the inoculations of *Vicia sativa* with artificial cultures of the vetch tubercle organism, inoculations were also made of young plants of *Dolichos sinensis* with organisms from the same culture but no tubercles were developed while the inoculated plants of *Vicia sativa* developed tubercles.

But considering the almost universal infection of leguminous plants when grown in a state of nature it is difficult to believe that there are so many species as are represented by the different forms of bacteroids. Rather at the present time the question might be asked, does not the influence of the macrosymbiont upon the microsymbiont while within the tubercle fix a certain type of racial form and attenuation upon the microsymbiont until it shall have passed through normal conditions in the soil again and been restored to its original form and infecting power? The system of preventive inoculation depends largely upon the development of racial peculiarities and degrees of attenuation obtained by growing organisms in the presence of some deleterious substance, by cultivating them at certain temperatures for given periods of time, subjecting them to various degrees of atmospheric pressure, as by passing them through the bodies of other animals than those in which the organism is at first so virulent. While it is maintained by some that these racial peculiarities artificially produced remain fixed, there is evidence to show that after a time the attenuated organism may, by being subject

to certain normal influences, gradually regain its pristine characteristics and virulence.

This suggestion is only offered as a possible hypothesis for the explanation of apparent racial peculiarities in the microsymbionts of the tubercles. It must stand or fall only by a very comprehensive and thoroughgoing investigation. If it should be proven to be a correct one it would help to explain some of the conflicting observations upon the morphology of the organism.

Its solution one way or the other must be the crowning result of the remarkable series of investigations that have thus far contributed to a knowledge of one of the most abstruse problems of biological science, and would give a firm foundation for the most rational treatment of the economic phases of the subject.

Synonymy.

The question of generic synonymy and classification also deserves consideration. *Protomyces* and *Schinzia* to which the organism was referred at successive times by Frank can not stand because the fungi first associated with these genera would have precedence over the present one. *Bacillus*, to which Beyerinck referred it, can not be retained, since, as Prazmowski has shown, we do not at present know of an endogenous spore formation, and also for the reason that, even according to Beyerinck, the organism is not a true schizomycete. The latter reason would disqualify *Bacterium*, the location proposed by Prazmowski. Frank's *Rhizobium* is based on a micrococcoid form which at least could only represent a minute form of the organism, leaving out of consideration entirely, as Frank does, the hypha form as a part of his *Rhizobium*.

Laurent is not justified then in emending by expansion a genus based on a micrococcoid form, to include a complex plant the important characters of which the author of *Rhizobium* says form no genetic connection with his genus. Likewise it can not be justly emended from either Frank's or Laurent's *Rhizobium* to embrace only the bacteroids of the tubercles as Schneider has done.

However, Schrœter's *Phytomyxa* antedates Frank's *Rhizobium*. It is, moreover, a very easy matter to determine the fungus from Schrœter's description of *Phytomyxa*, even though the author may have erred in placing the genus among

the *Myxomyceteæ*. In fact *Phytomyxa* was erected to represent exactly the morphological characters which we find present in the fungus in the tubercles.

Laurent, probably from the analogy of the form of some of the bacteroids and the forked individuals in his artificial cultures to the various stages of longitudinal division, as Metchnikoff[125] terms it, of *Pasteuria ramosa*, places it in the family *Pasteuriaceæ*. There does notseem to be any good evidence that longitudinal division occurs in the organism of the tubercles, as is described for *Pasteuria*, but that these forked forms are derived in an entirely opposite manner, from that which obtains in *Pasteuria*, *i. e.*, by growth instead of longitudinal division, or what seems, more properly speaking, from Metchnikoff's descriptions to be a stellate or radiate division, beginning with numerous invaginations upon the external surface and proceeding toward the center until finally the quadrants and octants present a division approaching the longitudinal.

It still remains to note certain remarkable phenomena observed by the present writer in one of the cell cultures of the vetch tubercle organism. The microscope was focussed upon several individuals representing various lobed forms to observe their development. Sketches were made of the position and form of all the individuals in the field of the microscope in order that their development might be accurately recorded. In the course of twenty-four hours one of the individuals had disappeared from view, and now and then minute motile organisms swept across the field. During that day one of the larger lobed forms disintegrated by the loss in some way, which was not observed because interrupted observations were made, of the dense portions of protoplasm at certain points near the periphery. The most remarkable phenomenon, however, was the fact that one of the individuals, the form of which might be described as representing the union of two clavate bodies by their larger ends, was moving about sluggishly as if drawn by something attached to one end. For ten to fifteen minutes it moved about within the field of the microscope with a slow oscillatory movement combined with the progressive movement, when it disappeared from view. These observations have suggested the possibility of the formation of zoospores within the larger of the individuals in artificial cultures and in the buddings or enlargements of the hyphæ within the tubercle.

[125] Ann. d. l'Institut Pasteur II (1888). 165–170.

Little value is attached by the writer to these observations since it was impossible at that time to repeat them, for in a few days his labors were to be removed from Alabama to New York, and during the move the infusion of *Vicia sativa* with which it was designed to make media to prosecute the study farther became contaminated. During the busy period of organizing work in a new field the organism died before fresh culture media could be made.

Laurent did not observe a motile stage. Beyerinck observed motile forms which agree in size with the smallest forms (0.2μ) obtained by myself. If Frank's micrococci and Prazmowski's swarmers could be regarded as the same forms represented by these small individuals the possibility of there being zoospores would be strengthened. Should the presence of zoospores be confirmed it would indicate a relationship to the lower *Phycomycetes*. It will be remembered that Vuillemin (l. c.) placed the organism in the *Chytridiaceæ*, but the zoospores of his *Cladochytrium tuberculorum* were 7μ in diameter, a size much greater than any except possibly some of the very largest of the organisms obtained by other investigators, and since his studies were made in late autumn on old tubercles there may have been some chance of monads occurring in the tissue of the tubercles.

While in some characters, as noted above, the tubercle organism is very much like *Cladochytrium tenue*, yet in the sum of essential characters it departs too widely from that genus, so that even if it should eventually be clearly shown to be one of the *Chytridiaceæ*, it would still be referable to *Phytomyxa*.

Cornell University.

EXPLANATION OF PLATES XII–XV.

PLATE XII.—Tubercles of Vicia sativa, from photographs.

PLATE XIII.—Fig. 4. Young tubercle, magnified, showing affected root hair. —Fig. 5. Same root hair more magnified, showing form of infecting thread.—Fig. 6. Another view of fig. 5.—Fig. 7. Section of outer portion of tubercle with root hair, showing entering infecting thread.—Fig. 8. Section of young tubercle with infecting thread *in situ* showing enlargement and buds; *en*, endodermis; *pe*, pericambium; *ph*, phloem; *x*, xylem.

PLATE XIV.—Fig. 9. Infecting thread drawn to larger scale.—Fig. 10. Portion of bacteroid tissue containing branching threads of *Phytomyxa*; *n*, nucleus of tubercle cells.—Figs. 11 and 12. Organisms in pure culture of *Phytomyxa* from vetch tubercle.—Fig. 13. Bacteroids of *Vicia sativa* tubercle.—Figs. 14 and 15. Bacteroids of *Medicago denticulata* tubercle. The scale in 13, 14 and 15 is $\frac{1}{2}^{mm}$, and the objects are magnified thirty times more than the scale.

PLATE XV.—Inoculation. Water culture of *Vicia sativa*. Nos. 1 and 4 inoculated with organisms from pure culture of *Phytomyxa* from *Vicia sativa* tubercles. From photograph.

Flowers and insects. XI.

CHARLES ROBERTSON.

STELLARIA MEDIA Sm.[1]—"Nat. from Eu."—The plant was observed in bloom from March 14th to Oct. 25th. It is not abundantly visited except in early spring, when the flowers form quite conspicuous patches. At this time frequent cross-pollination is inevitable. On seven days, March 25th to April 29th, and Oct. 15th, I observed the following visitors, all sucking:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿; (2) Ceratina dupla Say ♂; (3) Osmia lignaria Say ♂; (4) Nomada bisignata Say ♂; (5) N. luteola Lep. ♂; *Andrenidæ:* (6) Panurgus? andrenoides Cr. ♂; (7) Andrena sayi Rob. ♂; (8) A. illinoensis Rob. ♀; (9) A. flavo-clypeata Sm. ♂; (10) A. cressonii Rob. ♂♀; (11) A. forbesii Rob. ♀; (12) Augochlora pura Say ♀, ab.; (13) Halictus lerouxii Lep. ♀; (14) H. ligatus Say ♀; (15) H. fasciatus Nyl. ♀; (16) H. pilosus Sm. ♀; (17) H. gracilis Rob. ♀; (18) H. confusus Sm. ♂♀; (19) H. stultus Cr. ♀; (20) Colletes inæqualis Say ♂; *Chalcididæ:* (21) Smicra torvina Cr.; *Ichneumonidæ:* (22) Pimpla novita Cr. (determined by Ashmead); *Tenthredinidæ:* (23) Dolerus arvensis Say.

Diptera—*Mycetophilidæ:* (24) Sciara sp.; *Syrphidæ:* (25) Chilosia capillata Lw.; (26) Melanostoma obscurum Say; (27) Platychirus quadratus Say; (28) Syrphus ribesii L.; (29) S. americanus Wd.; (30) Mesograpta marginata Say; (31) Eristalis tenax L.; (32) E. æneus F.; (33) E. dimidiatus Wd.; (34) Brachypalpus frontosus Lw.; (35) Syritta pipiens L.; *Tachinidæ:* (36) Gonia frontosa Say, ab.; (37) G. exul Will.; *Sarcophagidæ:* (38) Cynomyia sp.; *Muscidæ:* (39)

[1] See Axell: Om anordningarna för de Fanerogama Växternas Befruktning; Lubbock: British Wild Flowers in Relation to Insects; Müller: Fertilization of Flowers, and Weit. Beobachtungen; Henslow: Self-fertilization of Plants; Anna Bateson: The Effects of Cross-fertilization on Inconspicuous Flowers, Annals of Botany, I; Meehan: Contributions to the Life Histories of Plants, III, Proc. Acad. Sci. Phila., 1888; Battandier: Sur quelques cas d'heteromorphisme, Bull. Soc. bot. France, XXX; Ludwig: Botan. Ver. d. Provinz Brandenburg, XXVI; MacLeod: Untersuchungen über die Befruchtung einiger phanerogamen Pflanzen d. Belgischen Flora, Bot. Centralblatt, XXIII; Schulz: Beiträge zur Kenntniss d. Bestäubungseinrichtungen u. Geschlechtsvertheilung bei den Pflanzen.

Pollenia rudis F.; (40) *Musca domestica* L.; (41, 42) Lucilia spp.; (43) L. cornicina F.; (44) Myospila meditabunda F.; *Anthomyidæ:* (45) Chortophila sp.; *Cordyluridæ:* (46) Scatophaga squalida Mg.

Lepidoptera—*Nymphalidæ:* (47) Pyrameis huntera F.; *Lycaenidæ:* (48) Lycaena pseudargiolus B.-L.

Hemiptera—*Lygaeidæ:* (49) Lygaeus turcicus F.

	Bees.	Other Hymenoptera	Diptera	Other insects.	Total.
In Low Germany—Müller....	15	1	8	1	25
In Illinois.....	20	3	23	3	49

MALVA ROTUNDIFOLIA L.[2]—"Nat. from Eu."—In the Fertilization of Flowers Müller says that the flowers of this species attract few insects, and he gives a list of visitors which compares very unfavorably with the list taken on flowers of *M. sylvestris.* In Illinois the plant seems to have little difficulty in acquiring a useful set of visitors. The subjoined list compares favorably with Müller's list of visitors of *M. sylvestris.* The plant blooms from April to November. On eleven days, between May 14th and October 9th, the following insects were observed visiting the flowers:—

Hymenoptera—*Apidae:* (1) Apis mellifica L. ☿, s., freq.; (2) Bombus pennsylvanicus DeG. ♀, s.; (3) Melissodes bimaculata Lep. ♂, s.; (4) Ceratina dupla Say ♀, s. and c. p.; (5) Nomada incerta Cr. ♀, s.; (6) Calliopsis andreniformis Sm. ♂♀, s. and c. p., ab.; *Andrenidae:* (7) Agapostemon bicolor Rob. ♂♀, s. and c. p.; (8) A. radiatus Say ♂, s., freq.; (9) Augochlora pura Say ♂♀, s.; (10) Halictus pectoralis Sm. ♂♀, s.; (11) H. similis Sm ♀, s. and c. p.; (12) H. coriaceus Sm. ♀, s.; (13) H. ligatus Say ♂♀, s.; (14) H. fasciatus Nyl. ♀, c. p., freq.; (15) H. pilosus Sm. ♀, s.; (16) H. zephyrus Sm. ♂, s., (17) H. confusus Sm. ♂♀, s., ab.; (18) H. illinoensis Rob. ♀, s.; (19) H. stultus Cr. ♂, s.; (20) Prosopis affinis Sm. ♀, f. p.

[2] See Sprengel: Das entdeckte Geheimniss; Lubbock: British Wild Flowers in relation to Insects; Henslow: On the Self-fertilization of Plants—Trans. Linn. Soc. II. 1; On the fertilization of flowers by bees and other insects—Journ. Roy. Hort. Soc. London, VI; Müller: Fertilization of Flowers, and Weit. Beobachtungen; MacLeod: Pyreneenbloemen en hare bevruchting door insecten; Keller: Proc. Acad. Nat. Sci. Phila., 1892, 452.

Diptera—*Syrphidae:* (21) Mesograpta marginata Say, s. and f. p.; *Muscidae:* (22) Lucilia cornicina F., s.; *Anthomyidae:* (23) Chortophila sp., s., freq.

Lepidoptera—*Rhopalocera:* (24) Pieris rapæ L., s.

Coleoptera—*Malachidae:* (25) Collops 4-maculatus F., f.p.

	Halictus.	Other bees.	Other insects.	Total.
In the Pyrenees—MacLeod	–	1	–	1
In Low Germany—Müller	2	3	1	6
In Illinois	13	7	5	25

SIDA SPINOSA L.—"Nat. from the tropics."—The stigmas receive pollen from the dehiscent anthers, but may be effectually dusted with pollen from other flowers in case of early insect visits. Later the styles bend and turn the stigmas in among the anthers, so that thorough self-pollination is insured. The plant has small yellow flowers. It was noted in bloom from July 25th to October 3d, and the following visitors were observed:—

Hymenoptera—*Apidæ:* (1) Bombus americanorum F. ♂☿, s.; (2) Ceratina dupla Say ♀, s. and c. p.; *Andrenidæ:* (3) Augochlora pura Say ♂, s.

Lepidoptera—*Papilionidæ:* (4) Pieris protodice B.-L.; (5) P. rapæ L.; (6) Colias philodice Gdt.; (7) Terias lisa B.-L.; *Hesperidæ:* (8) Pyrgus tassellata Scud.

ABUTILON AVICENNÆ Gærtn.—"Adv. from India."—The flowers are yellow and occupy very inconspicuous positions under the large leaves. They are spontaneously self-pollinated in absence of insects, but may be cross-pollinated in their presence. For a long time I thought that nectar was wanting and that visitors never occurred, but in three days, August 21st to September 19th, I captured the following insects on the flowers:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Bombus separatus Cr. ☿, s.; (3) B. americanorum F. ♂☿, s.; (4) Melissodes bimaculata Lep. ♀, s. and c. p.; *Andrenidæ:* (5) Halictus confusus Sm. ♀, c. p.; (6) H. fasciatus Nyl. ♀, s.; (7) H. coriaceus Sm. ♀, s.

Diptera—*Syrphidæ:* (8) Mesograpta marginata Say, f. p.; *Anthomyidæ:* (9) Chortophila sp., s.

Lepidoptera—*Papilionidae:* (10) Pieris rapæ L.; *Hesperidæ:* (11) Pholisora catullus F.

HIBISCUS LASIOCARPUS Cav.—With the exception of a single specimen of *Hibiscus militaris*, this is the only indigenous species of Malvaceæ which I have found in my neighborhood, and, as might have been expected, is the only one in which spontaneous self-pollination is impossible. It grows in swamps. The stalks, several of which form a cluster, rise from one to two metres, each stalk exposing two or three large flowers at a time.

The flowers are white or rose-tinted, with a crimson centre. They measure from eight to ten centimetres in length, and expand from nine to eleven centimetres, or more. The lower petals are directed horizontally; the upper are bent strongly upward like a vexillum, so as to be nearly perpendicular to the lower. The column lies near the lower petals and for about three centimetres from its base is provided with free filaments, which project upwards and sideways. On account of the flower being in an incipient stage of irregularity, the column still retains some useless filaments on the lower side, whose anthers seldom touch the bees. The five large capitate stigmas, which form a circle from nine to thirteen millimetres across, are advanced one or two centimetres before the nearest anthers, so that there is no chance of spontaneous self-pollination.

When visiting the flower, bees land upon the base of the column. The latter is bent upwards in such a position that the bees touch the stigmas before they alight. After sucking, the bees crawl out over the filaments and upon the lower petals and leave the flower without again touching the stigmas.

After alighting upon the column, *Emphor bombiformis*, which is the characteristic visitor, turns to the right or left and thrusts its proboscis into one nectary after another until it reaches the narrow interval between the column and the lower petals. Then it often turns back and inserts its proboscis into the nectary on the other side. Commonly, however, it fails to squeeze under the column to visit the nectary which lies there, and it often neglects to turn back for the nectary on the other side, and so leaves the flower without extracting the sweets from all the nectaries. Seventy-six individuals which I watched at this work missed eighty-one

nectaries in seventy-six flowers. On the other hand, *Bombus americanorum*, which is larger, more time-saving and less familiar with the flower, more frequently neglects to visit the nectary under the column and seldom turns back, so that it misses the lower nectaries even more frequently. I saw fifty-six individuals of this species miss eighty-five nectaries in fifty-six flowers. Both species also often miss the lower nectaries because, after inserting their proboscides into the upper ones and finding them empty, they arrive at the erroneous conclusion that the lower ones are in the same condition.

In their economy, the flowers of this plant and the bee first mentioned, *Emphor bombiformis*, stand in a very close relation. With the exception of single individuals taken on flowers of *Cephalanthus occidentalis* and *Ipomœa pandurata*, I have never taken this bee on any other flower. On the *Hibiscus* I have never failed to find it in favorable weather, and I have found the males in the closed flowers in bad weather. No specimens have been observed by me except during the blooming time of the plant, from July 25th to Sept. 16th. The female is provided with a large loose scopa which seems to be specially fitted to retain the large pollen grains, and this is the only flower on which I have seen it collecting pollen. Accordingly, I think the bee depends exclusively upon Hibiscus pollen for food for its larvae. I have seen the female making excavations for her nest within a few yards of the plants.

The only other insect at all frequent on the flower is *Bombus americanorum* F. ♂♀☿. I have never found this bee half as abundant, and commonly absent altogether, while the *Emphor* was abundant. This bumble-bee never collects the pollen. In addition to these insects I have seen the flowers visited for honey only by *Melissodes bimaculata* Lep. ♂♀ and by single individuals of *Bombus separatus* Cr. ♀, *Entechnia taurea* Say ♂, *Megachile brevis* Say ♂, *Euphoria sepulchralis* F. and *Trochilus colubris* L.

HIBISCUS TRIONUM L.[3]—"Adv. from Eur."—The five capitate stigmas stand close together, and pollen only touches the edges next to the dehiscent anthers. Most of the stigmas are thus free from pollen and can be effectually cross-pollinated in case of insect visits. After the flowers close, the styles bend outward and downward forcing the stigmas

[3]See Sprengel: Das entdeckte Geheimniss.

among the anthers so as to cover them with pollen. Thorough self-pollination is, therefore, only effected by a special movement of the stigmas, and only occurs after the flower has been exposed to insects. I have seen it visited only by a single individual of *Pieris rapæ* L.

GERANIUM CAROLINIANUM L.—The plant is common, blooming from May 23d to July 13th. The stem rises from 2 to 4^{dm}, is diffusely branched and bears numerous pale rose-colored flowers, which are not crowded so as to form an attractive combination.

The corolla is small, measuring about 7^{mm} across. In forms observed by me there are ten perfect stamens. The flowers are imperfectly proterandrous. The anthers of the inner circle are so closely approximated to the stigmas, that in absence of insects, spontaneous self-pollination may readily occur.

The flowers are adapted to small bees. June 10th I observed the following visitors:

Hymenoptera—*Apidæ:* (1) Alcidamea producta Cr. ♂♀, s., freq.; (2) Osmia conjuncta Cr. (=4-dentata Cr. ♂) ♀, s.; (3) Calliopsis parvus Rob. ♀, s. and c. p.; *Andrenidæ:* (4) Agapostemon radiatus Say ♀, s.; (5) Augochlora pura Say ♀, s. and c. p., freq.; (6) Halictus pectoralis Sm. ♀, s. and c. p., freq.; (7) H. tegularis Rob. ♀, s. and c. p.; (8) H. stultus Cr. ♀, c. p.; (9) Prosopis affinis Sm. ♀, s., freq.; *Eumenidæ:* (10) Odynerus sp., s., freq.

Diptera—*Syrphidæ:* (11) Mesograpta marginata Say, s., freq.; *Tachinidæ:* (12) Hyalomyia purpurascens Twns. s., one.

OXALIS VIOLACEA L.[4]—The scapes rise one decimetre, or more, high and expose an umbel of rose-purple flowers. The five petals expand 20^{mm}. At base they are approximated into a tube about 5^{mm} long, very wide in the throat, but obstructed by the ten stamens and five styles. The tube within is whitish, with greenish streaks proceeding from a greenish base. The calyx is about 4^{mm} long and is erect, aiding in giving firmness to the tube. In the long-styled form, spontaneous self-pollination is impossible, but in the short-styled form it may occur by the pollen falling upon the stigmas.

The plant is common and blooms from April 6th to June 10th. It is very abundantly visited by bees, mostly species

[4]See Trelease: The Heterogony of Oxalis violacea, Am. Nat. XVI; North American Geraniaceæ, Mem. Bost. Soc. Nat. Hist. IV; Trans. St. L. Acad. Science, V; Bot. Gaz. XII; Christy: Journ. of Bot. XXIII.

of small size. On eight days, between May 1st and 17th, I observed the following visitors:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s.; (2) Bombus americanorum F. ♀, s.; (3) B. pennsylvanicus DeG. ♀, s.; (4) Synhalonia speciosa Cr. (=Melissodes dilecta Cr. ♂) ♂ ♀, s., freq.; (5) Ceratina tejonensis Cr. ♂, s., (6) C. dupla Say ♂ ♀, s., freq.; (7) Osmia cognata Cr. ♂, s.; (8) O. albiventris Cr. ♀, s. freq.; (9) Nomada superba Cr. ♀, s.; (10) N. annulata Sm. (=articulata Cr. nec Sm.) ♂, s.; (11) N. sayi Rob. ♂ ♀, s., freq.; (12) N. cressonii Rob. ♂; *Andrenidæ:* (13) Andrena violæ Rob. ♀, s.; (14) A. ziziæ Rob. ♂ ♀, s.; (15) Agapostemon bicolor Rob. ♀, s.; (16) A. radiatus Say ♀, s.; (17) Augochlora pura Say ♀, s., ab.; (18) Halictus pectoralis Sm. ♀, s.; (19) H. forbesii Rob. ♀, s.; (20) H. lerouxii Lep. ♀, s. and c. p., ab.; (21) H. ligatus Say ♀, s. and c. p.; (22) H. fasciatus Nyl. ♀, s. and c. p., ab.; (23) H. pilosus Sm. ♀, s. and c. p., ab.; (24) H. confusus Sm. ♀, s.; (25) H. albipennis Rob. ♀, s.

Lepidoptera—*Rhopalocera:* (26) Phyciodes tharos Dru.; (27) Colias philodice Gdt., (28) Nisoniades brizo B.-L.

MELILOTUS ALBA Lam.—"Adv. from Eur."—The plant is common along side-walks. The stems rise from 6 to 12^{dm}, or more, in height and bear a profusion of spikes crowded with white blossoms. The flower measures about 4^{mm} in length to the tip of the keel. The calyx tube measures about 1^{mm} in depth, so that the nectar is easily accessible to short-tongued insects. The flower agrees in all essentials, except color, with that of *M. officinalis*, as described and figured by Müller in Fertilization of Flowers, 180. Müller saw *M. alba* visited by *Apis mellifica* L. ☿, *Macropis labiata* Pz. and *Empis livida* L.

The following were observed on June 23d and 25th:—

Hymenoptera—*Apidæ:* (1) Apis mellifica L. ☿, s., ab.; (2) Bombus separatus Cr. ☿, s.; (3) Ceratina dupla Say ♀, s. and c. p.; (4) Megachile brevis Say ♀, s. and c. p.; (5) Alcidamea producta Cr. ♀, s. and c. p.; (6) Coelioxys 8-dentata Say ♂♀, freq.; (7) Epeolus fumipennis Say ♂, s., freq.; (8) Nomada incerta Cr. ♀, s.; (9) Calliopsis andreniformis Sm. ♂♀, s. and c. p.; *Andrenidæ:* (10) Macropis steironematis Rob. ♂♀, s. freq.; (11) Augochlora similis Rob. ♂, s.; (12) Halictus arcuatus Rob. ♀, s. and c. p.; (13) H. parallelus Say ♀, s.; (14) H. lerouxii Lep. ♂♀, s. and c. p.; (15) H. ligatus Say ♀, s. and c. p.; (16) H. fasciatus Nyl. ♀, s.;

(17) H. albipennis Rob. ♀, s. and c. p.; (18) H. confusus Sm. ♂♀, s. and c. p., ab.; (19) H. pruinosus Rob. ♂, s.; (20) Sphecodes arvensis Pttn. ♂, s.; (21) Colletes eulophi Rob. ♂♀, s.; (22) C. willistonii Rob. ♀, s.; *Vespidæ:* (23) Polistes pallipes Lep., s.; *Eumenidæ:* (24–26) Odynerus spp.; (27) Odynerus fulvipes Sauss.; (28) O. arvensis Sauss.; (29) O. foraminatus Sauss., freq.; (30) O. megæra Lep.; *Crabronidæ:* (31) Crabro interruptus Lep., freq.; (32) Oxybelus emarginatus Say; *Philanthidæ:* (33) Cerceris clypeata Dlb.; *Sphecidæ:* (34) Ammophila gryphus Sm.; (35) A. vulgaris Cr.; (36) A. pictipennis Walsh.; (37) A. intercepta Lep.; (38) Isodontia philadelphica Lep.; (39) Sphex ichneumonea L.; (40) S. pennsylvanica L.; (41) Priononyx atrata Lep.; *Pompilidæ:* (42) Pompilus sp.; (43) P. relativus Fox; (44) P. navus Cr.

Diptera—*Empidæ:* (45) Empis sp.; *Conopidæ:* (46) Oncomyia loraria Lw.; (47) Conops brachyrrhynchus Mcq.; *Syrphidæ:* (48) Platychirus quadratus Say; (49) Syrphus americanus Wd.; (50) Allograpta obliqua Say; (51) Sphaerophoria cylindrica Say; (52) Syritta pipiens L.; *Tachinidæ:*[6] (53) Cistogaster occidua Wlk.; (54) Ocyptera euchenor Wlk. freq.; (55) Jurinia apicifera Wlk.; (56) J. smaragdina Mcq.; (57) Cuphocera ruficauda v. d. W.; (58) Micropalpus fulgens Mg., ab.; (59) Phorocera edwardsii Will.; (60) Acroglossa hesperidarum Will., ab.; (61) Trichophora echinomoides Twns., ab.; (62) Oliviera americana Twns.; (63) Pseudomyothyria nigricornis Twns.; *Sarcophagidæ:* (64–65) Sarcophaga spp.; *Muscidæ:* (66) Cyrtoneura sp.; (67) Lucilia caesar L.; (68) L. cornicina F. —all s.

Lepidoptera—*Rhopalocera:* (69) Chrysophanus thoe B.-L.; (70) Thecla humuli Harr.; *Sesiidæ:* (71) Sesia sexfasciata Hy. Edw.

Coleoptera—*Scarabaeidæ:* (72) Trichius piger F., s.; *Cerambycidae:* (73) Typocerus sinuatus Newm., s.; *Mordellidæ:* (74) Mordella marginata Melsh., s.; *Curculionidæ:* (75) Centrinus sp.; (76) C. picumnus Hbst.; (77) C. scutellumalbum Say, freq.

Hemiptera—*Lygaeidæ:* (78) Lygaeus turcicus F., s.; *Pentatomidæ:* (79) Podisus spinosus Dal., s., one.

Carlinville, Ills.

[6]The Tachinidæ mentioned in this paper were determined by Mr. C. H. Tyler Townsend.

BRIEFER ARTICLES.

Difference between the common salt-wort and the Russian thistle.—Farmers' Bulletin no. 10, of the Department of Agriculture, on the Russian thistle and other weeds, has aroused some interest in the distinctive differences between the harmless saltwort *Salsola Kali* L. and the noxious Russian thistle *Salsola Kali* L., var. *tragus* DC. The former has existed on the Atlantic coast for nearly a century at least and appears to be indigenous there and also in saline localities in the Black Hills. It has never been regarded as a troublesome weed. The variety *tragus* was introduced into South Dakota from Russia about seventeen years ago and is now justly regarded as the worst weed in the northwest.

The two forms appear very much alike but it is a matter of importance that they should be distinguished.

The original description of the variety is as follows: "*β Tragus*, suberecta glabra viridis, alis subbrevibus subroseis vel roseis."—DC. Prod. XIII. 2. 187. It is given here in full because De Candolle's Prodromus is not as available to all botanists as one might wish. In addition to these characters the following may aid in distinguishing the variety from the species: The species *S. Kali* does not become bright red or magenta colored at maturity. The middle bract, or a bract-like leaf subtending the floral bracts, is usually much longer than the others. The calyx is dull white or slightly rose-colored and coriaceous; the wing on the back of the calyx lobes is thick and comparatively narrow, less prominent than the ascending lobe.

The variety *tragus* becomes rose-colored or bright magenta at maturity on the bracts and more or less on the branches and all parts exposed to the light. The bracts are nearly equal, or at least no one appears regularly throughout the plant to be two or three times longer than the others. The calyx is membranaceous and nearly always bright rose-colored. The wings on the back of the calyx lobes are thin and are much larger than the ascending lobes.

All of these characters vary. Otherwise there would be a specific difference. Color is of comparatively little value under different conditions of light and moisture but the characters of the calyx are reasonably constant.

The true Russian thistle, the same form which is causing so much trouble in North and South Dakota, has recently been received from Valentine, Nebraska, about seventy-five miles west of the Missouri river. It may be expected along railroads in all parts of the northwest, and care should be taken to kill it in these places before it goes to seed and becomes established.—L. H. DEWEY, *Washington, D. C.*

EDITORIAL.

THE MEETING of the American Association for the Advancement of Science next month promises to be an important one for botanists. It will be remembered that this is to be the first assembling of the new section of botany which was established at the Rochester meeting. In order to justify the division of the section of biology, if for no better reason, it behooves botanists not only to attend in numbers, but to prepare papers concerning their late researches to be read at the meeting. The committee which was appointed to secure some papers which should give a comprehensive view of the condition of the science of botany in this country, especially for the benefit of those who do not yet realize its development, has been active, and as a result are able to announce a number of papers from some of the foremost botanists. Each one selected by the committee to treat his own particular field is able to speak with authority.

THERE WILL come before the section and the Botanical Club, also, several reports of important committees, such as the committee on the formation of an American Botanical Society, and the committee on revision of the nomenclature of spermaphytes. There will also be some new business for the botanists to take hold of, the most pressing of which is the consideration of some method of reporting and publishing a periodical index to American botanical literature.

IMMEDIATELY at the close of the general meeting comes the assembling of the botanical congress, the first session occurring on August 23d. It is expected that a considerable number of representatives of foreign societies will be present at this time and that the report of the international committee on nomenclature will be presented. It is to be hoped also that some steps will be taken to coöperate with the "international committee on the revision of biological nomenclature" (terminology) in order to secure the betterment of our present confused terminology which every teacher must feel as an "old-man-of-the-sea" about his neck when he endeavors to give his students an idea of homologies in plants.

ALTOGETHER there is an outlook for the science of botany at the present time which is full of encouragement, and an amount of work to be done for its further advancement which is enough to kindle the ardor of every man who has a gram-meter of energy or a spark of zeal. In no better way can this be shown at present than by making arrangements to attend the Madison meetings. The place is a beautiful summer resort, and the most ample accommodations are being made for the comfort and entertainment of those who attend.[1]

[1] Any one desiring information about railway and hotel rates, etc., can obtain it by addressing Prof. C. R. Barnes, Local Sec'y A. A. A. S., Madison, Wis.

THE REPORT of the success of the A. A. A. S. committee in securing a table for investigators at the Naples Zoological Station will be found on p. 283. As botanists were asked to coöperate in this endeavor, and did so coöperate, and as the Station makes generous provision for the study of marine and littoral plants, and as it is quite possible that a botanist may make application for the use of this table, it would have been a gracious, not to say a just, thing to recognize botanists in the formation of the advisory committee, which is at present composed entirely of zoologists.

Probably Secretary Langley was deceived by his knowledge of the English language into thinking that the American Morphological Society was not composed wholly of *animal* morphologists, and the Association of American Anatomists entirely of *animal* anatomists.

CURRENT LITERATURE.

Minor Notices.

In a monograph illustrated by two carefully prepared plates with forty-two figures, Dr. J. W. Moll publishes his results of a critical and exhaustive study on the karyokinesis of Spirogyra, together with a brief outline of the method used.[1] The latter is a most commendable feature, as no work of this kind can be thoroughly understood without some knowledge of the method pursued.

In the introduction, the author gives a comparative *résumé* of the results of several eminent observers upon the details in question.

Certain details in method are unique, and cannot be wholly without interest. Short pieces of Spirogyra threads are fixed in Flemming's mixture, and after thorough washing and bringing into 90 per cent. alcohol by means of a dialyser, they are imbedded in small bits of celloidin in order to facilitate handling and correct orientation. The bits of celloidin with the imbedded threads, are now stained with gentian violet, imbedded in paraffin and sectioned on a microtome.

The author deals at some length with the finer details of structure of the nucleolus and plasm, which, by this method, are brought out with great clearness. The view, held by several authors, that the nucleolus furnishes the chromatic substance, is supported. After a

[1] MOLL, J. W.:—Observations on karyokinesis in Spirogyra. Sep. from Verh. d. k. Akad. v. Wetensch. te Amsterdam. Sect. II, 1. no. 9 (repaged).

discussion of the facts which seem to justify the conclusion, Dr. Moll says: "The chromatic substance, which will form the segments at an early stage leaves the nucleolus and is transferred into the nuclear plasm. At this stage the nucleolus assumes a modified shape, getting pointed at one side and at this point the chromatic substance leaves it, appearing in the nuclear plasm as small fragments, ranged in an intermediate, achromatic thread like the beads of a necklace; and thus a skein, containing chromatic substance, is formed.

Doubt is expressed as to the origin of the thread linking the chromatic fragments together, but it is thought probable that the thread is first formed from the nuclear plasm and that afterwards the chromatin flows out into it. The author is inclined to think further that the process of karyokinesis in Spirogyra is not essentially different from that in higher plants.

Many other interesting and important details are brought out which can only be appreciated and understood by a careful reading of the entire paper.—D. M. M.

THE thirty-fifth contribution from the Herbarium of Columbia College is entitled "An enumeration of the plants collected by Dr. Thomas Morong in Paraguay, 1888–1890," by Thomas Morong and N. L. Britton, assisted by Miss Anna Murray Vail. It is reprinted from the Annals N. Y. Acad. Sci. VII. 45–280. Dr. Morong's expedition to South America is a record of unusual courage and devotion to science, and this bulky, well wrought contribution is one of its results. The study of such material is peculiarly difficult and can only be thoroughly done at a few favored places. In this case, recourse was had to the great collections of Europe before the work could be completed. Full notes in the field and in the herbarium largely increase the value of this contribution to the South American flora. Some idea of the wealth of material obtained can be had from the statement that nine hundred and thirteen phanerogams (distributed through one hundred and three families), and fifty-three pteridophytes are enumerated, eighty-three of the former being described as new species. The largest families are Compositæ (103), Gramineæ (91), Leguminosæ (87), Cyperaceæ (47, and only two of them carices), Euphorbiaceæ (36), Solanaceæ (36), and Malvaceæ (31). Euphorbiaceæ and Solanaceæ yielded the largest number of new species.

A RECENT CONTRIBUTION from the Gray Herbarium, of Harvard University is announced as no. III of a new series, two previous papers published by Dr. Robinson in Proc. Amer. Acad. being regarded as nos. I and II. The present one contains "Additions to the Phænogamic Flora of Mexico, discovered by C. G. Pringle in 1891–

'92," and is credited to the joint authorship of Dr. Robinson and Mr. H. E. Seaton. Thirty-four new species and varieties are described.

MR. J. CHRISTIAN BAY, of the Missouri Botanical Garden, has just published a bibliography of the tannoids, being issued in advance from the fifth annual report. Such publications are exceedingly useful, and become necessary for the preparation of monographs. It will be remembered that the same author has previously published a similar bibliography of inulin.

A CHECK LIST of the plants contained in the sixth edition of Gray's Manual has been compiled by John A. Allen and issued from the Herbarium of Harvard University. The species have serial numbers, including the varieties, and show a total of 3,781. An appendix attempts to enumerate the additional plants found within the limits of the manual since the issue of the sixth edition, bringing the total number to 3,937.

PROFESSOR A. S. HITCHCOCK has published a Key to Kansas trees in their winter condition reprinted from the 8th biennial report of the Kansas State Board of Agriculture.

OPEN LETTERS.

The bibliography of American botany.

With respect to a yearly bibliography and reference-work of American botanical literature, I have been asked to submit the following points to fellow-workers:

1. American botanical literature is playing a very important rôle in our science. Therefore it will be a very necessary step to take to publish a work similar to Just's Jahresbericht which could furnish:
   (a) A list of papers and works in every department of botany, *absolutely complete.*
   (b) A review of each of these papers and works, short and perfectly *objective.*
2. A work of this kind ought to be published every year.
3. In order to bring forth such a work, the importance of which would be international, it ought to be published and sold separately, and not be assimilated by any report or periodical. In the latter case it would to many botanists be inaccessible. With special reference to the Smithsonian publications I will state that in other countries these are very expensive and hardly ever seen in private libraries. A work on American botanical literature should be made accessible to every botanist all the world over.
4. Therefore, the publishing should, as far as the business management goes, be in the hands of a publisher.

5. The work ought to be undertaken by a committee, and the literature treated after some such plan as the following:

1. Periodicals, Reports of societies. 2. Text- and hand-books, nomenclature. 3. Classification. *a*, Phanerogamæ. *b*, Cryptogamæ. 4. Floras; *a*, of North America, *b*, of other countries. 5. Morphology. 6. Anatomy. 7. Physiology (including Biology and Phaenology). 8. Microscopy and Technique. 9. Biography. 10. Travels. 11. Horticultural botany. 12. Agricultural botany. 13. Forest botany. 14. Medical and Pharmaceutical botany. 15. Varia.

6. The editor of the work should be assisted by authors sending him a reprint of each of their papers. He should distribute these among the members of the committee for reviewing, and the reprints ought to become the property of the members to whom the editor sends them.

7. Not later than April each year the editor should have the reviews in hand so that the whole work could appear in July.

The details of this plan are easily understood. All of us know how valuable Just's Jahresbericht is, owing to the reviews, and how little attention it pays to American literature. Of course we must appreciate that such a work as has been planned above is an international affair, and for this reason especially, I have not the least doubt that it would pay the publisher well.

I should be glad to give some of my time to such a work, doing the purely bibliographical work, and taking care of the reviews of the literature bearing on the subjects named above under 6, 7, and 8. I would like to associate with fellow-workers, and form a committee which could bring the matter before the meeting at Madison. Owing to the amount of material that I have brought together, it would be possible, by properly attending to the matter to issue a report for 1892 this fall. —J. CHRISTIAN BAY, *Missouri Botanical Garden.*

NOTES AND NEWS.

THE LINNÆAN medal was recently presented to Professor Oliver, for many years curator of the herbarium at Kew.

MR. D. T. MACDOUGAL, recently assistant in botany at Purdue University, has been appointed instructor in vegetable physiology at the University of Minnesota.

DR. PAX, of the University of Berlin, has been appointed Director of the Botanic Gardens at the University of Breslau, the position made vacant by the death of Dr. Prantl.

THE UNIVERSITY of Minnesota has established an inland biological station at Gull Lake. The lake is in Cass county, Minnesota, and the station is reached from Brainerd.

MISS ALICE EASTWOOD, formerly of Denver, Colo., has succeeded Mrs. Katherine Brandegee, as curator of the Herbarium of the California Academy of Sciences, and as acting editor of Zoe.—*Zoe.*

A LIST of the Hymenomyceteæ of Orleans county, N. Y., has been published by Dr. Charles E. Fairman, in the Proceedings of the Rochester Academy of Science, II. 154–167. The lists contain 126 species.

THE MICHIGAN Agricultural College in its exhibit in the Department of Liberal Arts at the Columbian Exposition is displaying the photographs of about 150 American botanists, together with a small number of foreign botanists.

IN THE *Bulletin de l'Herbier Boissier* I. 184–190, R. Chodat and O. Malinesco have published an article dealing with the polymorphism of the alga, *Scenedesmus acutus* Mey., accompanied by a plate illustrating this striking example of polymorphism.—BAY.

MISS FLORA N. VASEY, of the Department of Agriculture, Washington, D. C., is compiling a catalogue of all women doing *actual* work in botany either professional or amateur or both. Those wishing their names included will send full name and address with specialty to Miss Vasey.

IN *Grevillea* for June Dr. C. B. Plowright completes the life history of three Uredineæ, by showing that *Puccinia Festucæ* produces æcidiospores on Lonicera periclymenum, *Puccinia Agrostidis* on Aquilegia vulgaris and *Uromyces lineolatus* (found on Scirpus maritima) on Glaux maritima.

MR. ROBERT DOUGLAS, in a recent paper on coniferous forests read before the Nurserymen's Convention at Chicago, stated that "on the 500th anniversary of the discovery of this continent there will be choice evergreens in America, but like the buffalo, the elk and the antelope, they will be confined to public parks and private grounds."

BARON VON MUELLER proposes to prepare a volume completing Bentham's *Flora Australiensis*. His personal researches in Australia having begun in 1847 and his explorations having been continued ever since, he is pre-eminently prepared for such a work. It is a strange fact that this will be the first Flora for any of the great divisions of the globe.

A BIOGRAPHICAL SKETCH of Alphonse De Candolle, together with a complete bibliography of his writings is published in *Bulletin de l'Herbier Boissier* for April, having been prepared by H. Christ. The bibliography shows 229 titles, and it must be remembered that some of these titles represent large volumes, and in a few cases a series of volumes.

DR. DE CHALMOT has given[1] a continuation of his paper previously referred to here, and his results are the following: (1) The pentosanes decrease in the seeds during the germination, and appear again in the stems and roots; most probably they are transferred. (2) The total amount of pentosanes increases during germination, and it seems probable that seedlings can absorb them out of the soil. Pisum sativum and Zea Mays, as well as Tropaeolum were the material used.—BAY.

[1] Reprint from the American Chemical Journal, XV. 276–285.

THE NEXT meeting of the Australasian Association for the Advancement of Science will be held in Adelaide, South Australia, commencing on September 25, 1893, at which time South Australia will be at its best. There is no better time at which to visit Australia than when spring is merging into summer, and to naturalists this time of year is specially attractive.

DR. MAXIME SCHUMANN whose travels in Congo are well known has been at the Missouri Botanical Garden planning his long expedition in this country. He starts from Fort Smith, Kansas, and goes afoot as far as Albuquerque. From there he will go to El Paso, Mexico, and through that country, ending his tour at Vera Cruz. He intends to take a long time for this expedition.—BAY.

DR. JOHN M. COULTER has entered upon the Presidency of Lake Forest University, an institution with its preparatory and collegiate departments at Lake Forest, Ill., a suburb of Chicago, and its professional schools in Chicago. The large herbarium which he brought to Indiana University and so largely increased there goes with him to Lake Forest. Mr. Edwin Uline has been appointed Curator.

NUMBERS 82, 83 and 84 of "Die natürlichen Pflanzenfamilien" have just been issued. They contain Ochnaceæ and Stachyuraceæ by Gilg; Caryocaraceæ, Marcgraviaceæ and Theaceæ by Szyszylowicz; Quiinaceae and Icacinaceæ by Engler; Chlænaceæ by Schumann; Hippocrateaceæ by Lösener; Stackhousiaceæ, Staphyleaceæ, Aceraceæ, by Pax; Scrophulariaceæ by Wettstein; Lentibulariaceæ by Kamienski; Orobanchaceæ by Beck; Gesneriaceae by Fritsch.

THE SECOND SESSION of the Colorado Summer School of Science, Philosophy and Languages, will be held at Colorado Springs, Colorado, during the month of July, 1893. The botany will be in charge of Mr. Albert F. Woods, of the University of Nebraska. Mr. Woods' course will consist of lectures and laboratory work on the life history of typical representatives of the great groups of the vegetable kingdom, represented as far as possible by the flora of the region.

M. EPHREM AUBERT finds that the fleshy plants transpire less rapidly than other plants not only because of their form and mechanical hindrances to evaporation but because of the presence of organic acids in the Crassulaceæ and the Mesembryanthemaceæ, and of acids and gums in the Cactaceæ. The curve for water transpired by different regions of fleshy plants presents a minimum corresponding to the maximum of the curve of malic acid found in the same regions.

CHEMICAL AND physiological studies on the tannins have followed a course different from that of the older studies since the publications of F. Reinitzer and L. Braemer were issued (1889–'91), and since E. and O. Nickel improved the reagents hitherto employed. Professor Henry Trimble has just published the first volume of an extensive series of studies on these bodies, many of which have caused considerable trouble in the chemistry of plants.[1]—BAY.

[1] HENRY TRIMBLE:—The tannins; a monograph on the history, preparation, properties, methods of estimation, and uses of the vegetable astringents. With an index to the literature of the subject.—Philadelphia, 1892, Vol. I.

THE EXPERIMENTS concerning the assimilation of free nitrogen are still carried on in the Rothamsted Experiment Station. Sir J. B. Lawes and Professor J. H. Gilbert have published an important paper, reprinted from the Journal Roy. Agricult. Soc. of Engl. III. II. part iv, entitled, "The sources of the nitrogen of our leguminous crops." In the Rothamsted Memoranda for June, 1892, the plans of this well known station were published, and also a list of the papers hitherto published from the institution.—BAY.

ERYTHEA for May contains a first installment of new plants of the Pacific coast by Thomas Howell; notes on a new Californian *Fimbriaria* and on an interesting form of *Polypodium Californicum* by Marshall A. Howe; Professor Greene presents the first paper of a series entitled "Corrections in Nomenclature," replacing in the present one the untenable name *Jacksonia*, as applied by Robert Brown to an Australian genus of Leguminosæ, by *Piptomeris* Turcz. and changing the thirty-six species; also a long review, by the same writer of Professor Conway MacMillan's "Metaspermæ of the Minnesota Valley," in which the general tone of the work is commended and attention called to inaccuracies in bibliography.

A VERY complete investigation of the occurrence of starch and sugar, and the presence and function of diastase in leaves, is published in the *Journal of the Chemical Society* for May (pp. 604-677) by Horace T. Brown and G. Harris Morris. A good résumé of all previous work is given, with critical remarks. Their work warrants the opinion that the beginning of the change in the conversion of starch in the plant is dependent upon the action of the protoplasm, but that its continuance and completion is due to an enzym. They also conclude that cane sugar is an antecedent of the formation of starch by chloroplasts, and that cane sugar is translocated in the plant as dextrose and levulose, and the starch as maltose.

THE LABORATORY of marine biology of the University of Pennsylvania, at Sea Isle City, N. J., opens for its third season, during July and August. It has been thought best not to offer any special course of instruction during the coming season. There will be opportunities, however, for beginners by special arrangements with the professors and instructors who will be working at the laboratory during the season. The University especially desires that investigators and teachers of natural history shall avail themselves of the opportunities offered, and for them therefore no charge will be made except for glassware taken from the laboratory and reagents used. Students desiring instruction will be charged according to the amount of time devoted to them. The laboratory is very completely equipped both in the way of buildings and collecting apparatus.

LAST WINTER a memorial was circulated petitioning the Smithsonian Institution to support a table at the Naples Zoological Station. Thirteen copies of the memorial were sent out. Twelve bearing the signatures of nearly two hundred working biologists, representing about eighty universities, colleges, and scientific institutions, were returned and were presented in person to Professor S. P. Langley, secretary of the Smithsonian Institution. In response to the memorial the secre-

tary of the Smithsonian Institution announces that the Institution has secured a table at the Naples Zoological Station for the use of American investigators. Applications for the use of this table will be received at any time, and should be accompanied by credentials indicating that the candidate is qualified to carry on original investigation in some field for which especial facilities are offered at the Naples Station. These credentials should be accompanied by a statement of the history of the candidate as a student and investigator, together with a list of such original papers as may have been published by him. The application should be also accompanied by a statement of the character of the investigation which the candidate desires to pursue, and the dates between which he wishes to occupy the table.

Appointments will be made by the secretary of the Smithsonian for a specific period, and, in the consideration of the claims of the candidates, the secretary will probably avail himself of the counsel of an advisory committee of four, representing the National Academy of Sciences, the Society of American Naturalists, the American Morphological Society, and the Association of American Anatomists.[1]

Persons who may occupy the Smithsonian table are expected to make a report at the end of their term of occupation, or every three months in case of long residence at the station. It is expected that due credit will be given to the Smithsonian Institution in any publication resulting from studies carried on at its table, and the "Smithsonian Contributions to Knowledge" will probably be available for the publication of at least a part of the papers resulting from the Naples investigations.

All correspondence should be addressed to S. P. Langley, Secretary of the Smithsonian Institution, Washington, D. C.

IN THE May number of the *Bulletin of the Torrey Botanical Club* Mr. Carlton C. Curtiss has presented some useful work in the examination of the surface characters of the seeds of some of our native Orchids, and has shown that while such minute anatomical characters may be of occasional use they cannot be exclusively relied upon in revealing genetic relationship; Professor Thomas C. Porter has published a list of the grasses of Pennsylvania as exhibited by that state at the World's Fair, numbering 166; the same author discusses *Solidago humilis* and its allies, delimiting *S. Virgaurea*, *humilis*, and *alpestris* and describing several new varieties of the first named species; Messrs. C. H. Kain, Thomas Morong, and Frederick Coville give short biographical sketches of Francis Wolle, Thomas Hogg, and Dr. George Vasey; Mr. F. H. Knowlton raises the question as to the proper place for the insertion of the interrogation point when used to indicate some question in reference to the plant-name; and Mr. John K. Small supplements his Revision of Polygonum by further notes and descriptions of new forms.

[1] This committee consists of Dr. J. S. Billings, of Washington, chairman; Professor E. B. Wilson, of Columbia College, New York; Dr. C. W. Stiles, of Washington, and Professor John A. Ryder, of the University of Pennsylvania.

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